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URL of this article: http://heanoti.com/index.php/hn/article/view/hn20222

A Calculating Actual Stature of Elderly through Arm Span and Knee Height Measurements

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ABSTRACT

Background: Most of estimation height study was calculated with one predictor. This research tried to arrange regression model by combining two predictors. **Methods**: The type of study was observational with cross sectional design. The study population is aged 60-69 years old in Wonogiri District. The sample size of 136 included 65 men and 71 women with purposive sampling technique. Data collection technique is observation on anthropometry measurement. Data analyzed with Pearson Product Moment, Unpaired T-test and Linear Regression. **Results**: Arm span is positively correlated with value of p<0.001; r=0.886 in men and p<0.001; r=0.992 in women. Knee height is positively correlated with p value <0.001; r=0.989 in men and p<0.001; r=0.986 in women. The height estimated from the arm span–knee height formulas: Women height (cm) = 40.915+[0.457 x AS (cm)]+[0.818 x KH (cm)]. Men height (cm) = 34.426+[0.513 x AS (cm)]+[0.813 x KH (cm)]. The highest overestimation happen at Chumlea’s formula in men at women group (6.01 cm) and highest underestimation happen at Fatmah’s formula in women group (-0.72 cm). **Conclusions:** Arm span is more accurately used in women, whereas knee height is more accurate in men. Predictor combinations can be used to predict height more accurately.

Keywords: Arm span, Knee height, Combination predictor

INTRODUCTION

Background

The height predictors of the elderly who have been recommended by WHO are arm span and knee height[(1)]. The first height estimation formula was arranged by Chumlea in 1984 with knee height predictors. But, the estimation formula unsuitable to generalized in all individuals because each ethnic in various countries have different characteristics.

Many studies have been conducted in different countries to develop estimation formula based on arm span or knee height. However, the suitable predictors for each ethnic group are not the same. Studies in Ethiopia showed that arm span is the most significant predictor (p=0.001; r=0.901)[(2)], but in India showed that knee height is the best predictor of height for indigenous ethnic Indians (p=0.001; r=0.895)[(3)]. These results are supported by studies in Chile that arm span is predictor have strongest correlation with actual height in elderly (p=0.001; r=0.834)[(4)].

The calculation of height based on predictors would emerge the phenomenon of underestimation and overestimation. Indirectly this phenomenon would affect to body mass index (BMI) and nutritional status. Recent studies from Sweden showed a height difference based on arm span and actual height reached 15 mm in men and 5 mm in women. Thus phenomenon caused higher prevalence until 2.1% underweight in men and 1.5% in women. Whereas, on the overweight prevalence showed 5.8% lower in men and 7.4% in women[(5)].

The phenomenon of underestimation and overestimation also found in height calculated with knee height. Research in China found that overestimation of height in women amount 1.7 cm (p<0.025) and underestimation in men amount 3.7 cm ($p<0.001$). Similarly, the results of research in Japan showed overestimation in women amount 1.5 cm ($p<0.001$) and underestimation amount 1.2 cm ($p<0.001$) in men[6]. Whereas, studies from Sweden showed overestimation amount 2 cm ($p<0.001$) in men and underestimation amount 1 cm ($p<0.001$) in women[7]. Brazilian studies indicated overestimation of height which calculated based knee height happened especially in women respondents. Height difference between estimated and actual reached 2.22 cm ($p<0.001$) which effected to underestimation of BMI amount 10%[8].

There is any research in Indonesia which concern at estimate of height in the elderly with arm span and knee height. Estimation formula of Chumlea was only suitable for Indonesian men, whereas in women there was an overestimation amount 0.9 cm[9]. In 2008 an estimation formula for Indonesian elderly was arranged which showed that arm span has strongest correlation with actual height. P value showed $p=0.001$; $r=0.815$ in men and $p=0.001$; $r=0.754$ in women with sensitivity and specificity test results of 86.7 and 88.6[10]. However, research in 2010 showed that the formula still showed underestimation and overestimation phenomenon[11].

Purpose

Most of estimation height study was calculated with one predictor only. No researcher has yet combined the two predictors in one equation to estimate height. Based on this, the researchers tried to arrange the regression model by combining two predictors (arm span and knee height).

METHODS

Research Design

The type of research is observational analytic with cross sectional study. Cross sectional study is suitable for correlation research with the observation approach (point time approach)[12].

Study Subjects

Variables in this study include actual height as dependent variable, arm span and knee height as independent variables. The results of this study presented in men and women's groups.

Sample Size Determination

Study population at this study was individuals aged 60-69 years in Wonogiri sub district at January – July 2017. Inclusion criteria in this research are individuals in health conditions, able to stand upright and willing to be respondent by filling informed consent. The exclusion criteria in this study are when the individuals have unable stretched his or her arms properly (straight) because of a broken or physical disability and experiencing foot fractures and or using prosthetic limbs.

The sample selection method is purposive sampling with the consideration of people who have experience in nutrition of elderly in *Wonogiri*. The sample size was calculated by hypothesis testing for single population proportion in one sample whom 136 including 65 men and 71 women.

Measurements

Measurements on each respondent are repeated three times and then taken the mean value of the measurement results by standardized enumerator. The measurement results are recorded by the researchers on the provided sheet.

Arm span was measured using a device made by researchers. There is a tape measuring ("BUTTERFLY" *brand*) with a precision of 1 millimeters attached to the aluminum rod. Arm span was measured from the tip of the middle finger of one hand to the tip of the middle finger of the other hand with the individual standing with their back to the wall with both arms abducted to 90°, the elbows and wrists extended and the palms facing directly forward. The height estimated from the arm span was calculated through the Fatmah formulas:

$$\text{Women height (cm)} = 28.312 + [0.784 \times \text{AS (cm)}]$$
$$\text{Men height (cm)} = 23.247 + [0.826 \times \text{AS (cm)}]$$

Knee height is measured with knee height caliper belonging to Nutrition Laboratory of Public Health Faculty, Diponegoro University with accuracy of 1 millimeter. Measurements were performed on the left knee with the perfect sitting position (upright body, hands free down and facing directly forward). Make sure each knee forms 90° angle, consisting of a fixed part, which has been positioned in the plantar surface of the foot (heel) and movable part, which was positioned over the patella. The height estimated from the knee`s height (KH) was calculated through the Chumlea formulas:

Women height (cm) = 84.88 + [1.83 x KH (cm)] - [0.24 x age (years)]
Men height (cm) = 64.19 + [2.02 x KH (cm)] - [0.04 x age (years)]

Actual height is measured by microtoise "GEA" SH-2A series with accuracy of 1 millimeter. Standing height was measured with microtoise against the wall on barefooted subjects, with their heels together and the heels, buttocks touching the wall.

Statistical Analysis

Validity and reliability in this study was conducted with the measuring instruments and enumerators that have been standardized by professionals in the field of nutrition. Normality test is used to know the distribution of variable data, determine hypothesis test and presentation selection. Normality was evaluated using the Kolmogorov-Smirnov test on IBM SPSS Statistics 20 program.

For knowing correlation of arm span and knee height to actual height it was used Pearson Product Moment test with Confidence Interval is 95%. Linear regression is used to construct regression models based on arm span and knee height. The quality of the formula is seen through the value of discrimination (value R^2) and calibration (ANOVA test results). A formula have good discrimination if the value of R^2 approaches 1 and good calibration is gif the ANOVA test results showed $p < 0.05$. For the comparison of estimated and measured values it was used unpaired t-test. The test results are said to be good when it shows no difference between predictor height and actual height (p value > 0.05).

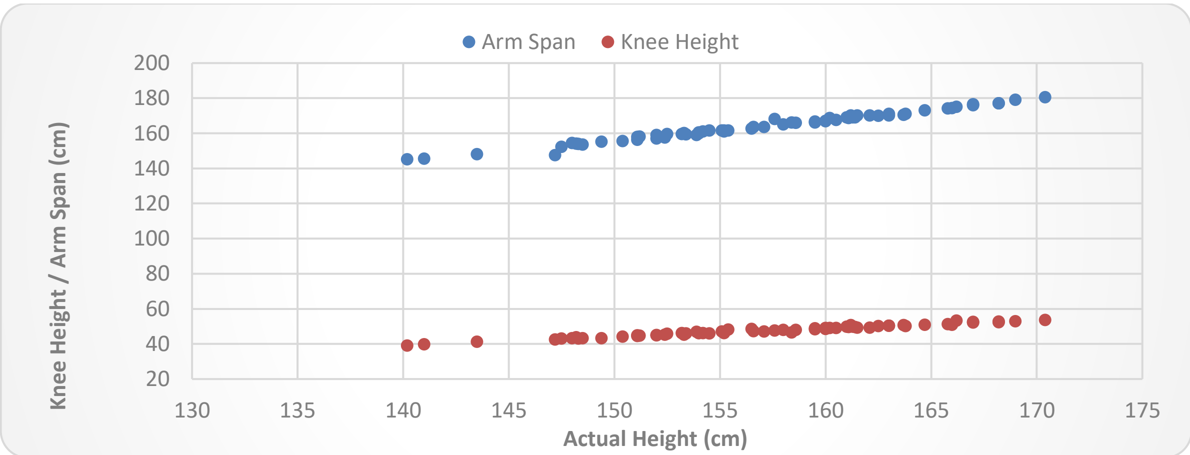
Ethical Clearance

The study was approved by the Ethics Committee on Public Health Faculty, Diponegoro University on July 14, 2017 with Number 165 / EC / FKM / 2017.

RESULTS

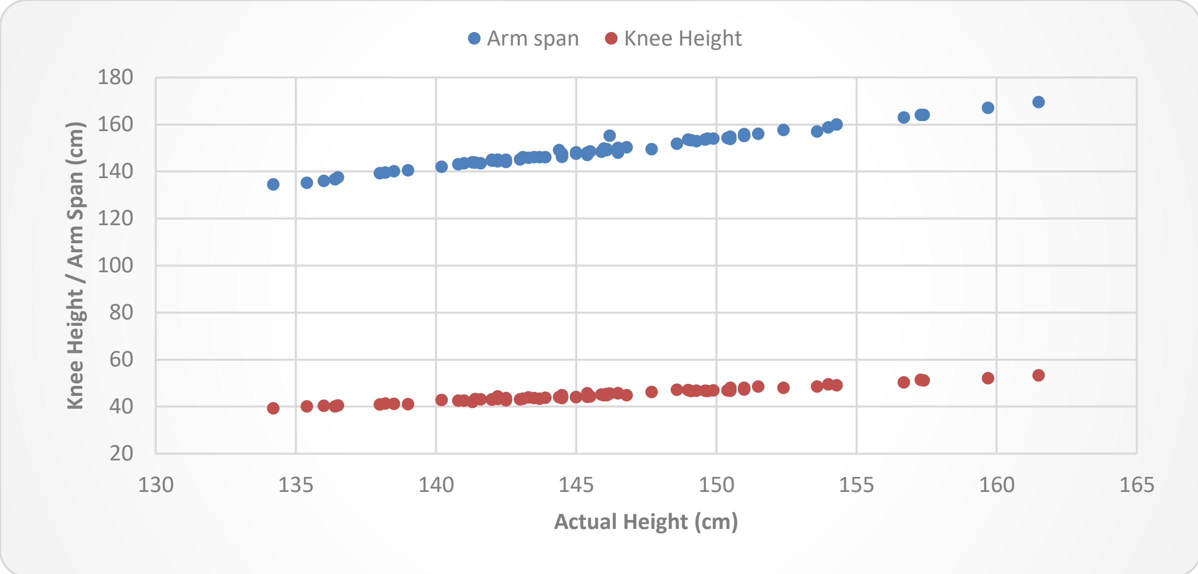
Correlation of Arm Span and Knee Height with Actual Height

The results showed a strong positive correlation between arm span and actual height in men with p value <0.001; r=0.886 and p<0.001; r=0.992 in women. It is also found that there is a very strong positive correlation between knee height and actual height. The results show p<0.001; r=0.989 in men and p<0.001; r=0.986 in women. Correlation test results are shown in Figure 1 and Figure 2.



Note: Statistical analysis with Pearson Product Moment. Arm span and knee height is positively correlated with p<0.001; r=0.886 and p <0.001; r=0.989.

Figure 1. Correlation Analysis in Men Group



Note: Statistical analysis with Pearson Product Moment. Arm span and knee height is positively correlated with p<0.001; r=0.986 and p<0.001; r=0.992 in women

Figure 2. Correlation Analysis in Women Group

Regression Model

The regression model for combination predictors showed p <0.001; R^2=0.991 in men and p<0.001; R^2=0.984 in women. It is mean that the regression model has good value in discrimination and calibration value. The height estimated from the arm span – knee height formulas:

Women height (cm) = 40.915 + [0.457 x AS (cm)] + [0.818 x KH (cm)]
Men height (cm) = 34.426 + [0.513 x AS (cm)] + [0.813 x KH (cm)]

Mean Difference between Actual Height and Prediction Height Result

Table 1. Analysis Mean DifferenceResult

Predictor	Height	Man	Woman
Arm span	Actual	157.0 ± 6.92	145.4 ± 5.78
	Estimation of Fatmah	158.6 ± 6.81	145.1 ± 5.76
	Mean Difference	1.60	- 0.72
	(Estimation - Actual)	(1.40 -1.80)	(- .89 – (- .54))
	Sign	<0.001	<0.001
Knee Height	Actual	157.0 ± 6.92	145.5 ± 5.78
	Estimation of Chumlea	157.3 ± 6.67	151.8 ± 5.5
	Mean Difference	0.30	6.01
	(Estimation - Actual)	(0.03 – 0.56)	(5.75 – 6.27)
	Sign	0.028	<0.001
Combination	Actual	157.0 ± 6.92	145.4 ± 5.78
	Combination	157.1 ± 6.89	145.8 ± 5.75
	Mean Difference	- 0.10	- 0.02
	(Combination - Actual)	(- 0.16 – 1.55)	(- 0.18 – 0.09)
	Sign	0.956	0.511

Note:
Height calculated in centimeter. Statistical analysis was used is unaired t test.. There are no significant different between estimation height based Chumlea’s formula in men and combination predictor formula. The highest overestimation happen at Chumlea’s formula in men at women group (6.01 cm) and highest underestimation happen at Fatmah’s formula in women group (- 0.72 cm). Combination predictor formula produce the lowest mean difference.

Mean difference is used to indicate the difference in predicted height to actual height, greater value of difference means mean more inaccurate the predictor. If the results indicate a negative sign means an underestimation and if positive means overestimation.

In men group, smallest difference was found in the combination predictors and highest mean difference was obtained in arm span. The underestimation phenomenon occurs in predictor combinations, but in arm span and knee height caused overestimation. In women group, lowest mean difference was shown in the estimation results based on combined predictors. The phenomenon of overestimation occurs in knee height and underestimation phenomenon occurs in arm span. Different test results are shown in Table 1.

DISCUSSION

In this study obtained that arm span more suitable for women. This is in line with other studies showing the coefficient of $p<0.001$; $r=0.891$ in women and $p<0.001$; $r=0.840$ in men. However, in other studies was found that arm span was more suitable for men ($p<0.001$; $r=0.970$) than women ($p<0.001$; $r=0.890$)(8). Study was showed a large correlation in men $p<0.001$; $r=0.815$ and $p <0.001$; $r =0.754$ in women(7).

The results of this study indicate that knee height predictors are more suitable men than for women. This is in line with the research that shows the correlation between knee height to height actual $p<0.001$; $r=0.876$ in men and $p<0.001$; $r=0.770$ in women(13). However, it is not in line with previous studies that showed $p<0.001$; $r=0.927$ in men and $p <0.001$; $r=0.877$ in women. Each bone has a length correlation with other bones. The higher body will have the longer bones of the body to although not always the same because there are factors that affect such as gender, races and ethnic(14).

Long bones such as arms and legs, though more fragile due to mineral loss, but wouldn't change with age. Arm span and actual height in children increases with age but the rate of improvement varies between gender and ethnicity. But, in the middle adult age the anthropometric measurement included actual height is reduced. In normal growth, arm span is approximately 1 cm shorter than actual height, in the adolescent arm span equal to actual height, whereas in the adult arm span exceeds the height about 5 cm, longest arm span is found in boys from African and Americans(15).

According to A.L Krober theory who classified the human races in the world in 4 groups namely Mongoloid, Negroid, Caucasoid and special race. Mongoloid spread across the Asian region and a small part of America. The Negroid race spread over the African and a small part of Melanesian (Papua). The Caucasian race has large, white, and blue-eyed features that inhabit most of Europe and the Mediterranean. Special race is a race that is not included in the three races mentioned earlier. This race exists only in certain areas, for example Veloid races found in the interior of Sri Lanka and South Sulawesi, Indonesia(16). Caucasoid have a medium to tall stature, while the Mongoloid are medium tall to medium short and Negroid, tall to very short(17). Chumlea composed a regression with knee height predictors using a sample of the European population where the population including in the Caucasian race. Thus, Chumlea's regression equation is unsuitable if applied to Mongoloid races in Indonesia.

In theory, the human body shape based on genetic can be divided into Ectomorph, Mesomorph and Endomorph(18). Ectomorphs tend to have a lean build, long limbs, and small muscle bellies. Even if an ectomorph manages to put on weight, they may still look skinnier than they are, particularly in the calves and forearms. The mesomorphs tend to have wide shoulders, a narrow waist, relatively thin joints, and round muscle bellies. This body shape will directly affect have longer arm span. It can be argued that the ectomorph group will have a shorter arm span than the endomorph group, but the group has higher knee height than the endomorph group(19). Thus, it indirectly affects the accuracy of the predicted outcome of the body based on arm span and knee height.

The research on predictive combination regression model should be continued by increasing the number and variation of race and respondent's tribe in order to know how far the regression model can be applied.

CONCLUSION

Arm span is positively correlated with the height of the elderly with a value of $p<0.001$; $r=0.886$ in men and $p<0.001$; $r=.0992$ in women. Arm span as stature predictor more suitable for women than men. Knee height is positively correlated to elderly height with p value <0.001; $r =0.989$ in men and $p<0.001$; $r =0.986$ in women. Knee height as stature predictor more suitable for men than women.

The combination predictor showed the highest R^2 in both male and female groups. There are the formula for predict stature with combination predictors:

$$\text{Women height (cm)} = 40.915 + [0.457 \times \text{AS (cm)}] + [0.818 \times \text{KH (cm)}]$$
$$\text{Men height (cm)} = 34.426 + [0.513 \times \text{AS (cm)}] + [0.813 \times \text{KH (cm)}]$$

Underestimation occurs in a combination of predictors in men and women with the smallest average difference compared with the long and high knee predictors.

Need to research with more number of samples and races in predictor combinations regression.

REFERENCES

1. World Health Organization. Physical Status: The Use and Interpretation of Anthropometry. Geneva: WHO Expert Committee; 1999.
2. Kwok T, Whitelaw MN. The Use of Armspan In Nutritional Assessment of The Elderly. Journal of American Geriatrics Society. 1991;39:492-496.
3. Tyagie SK, Anup KK. Body Composition and Fat Distribution Pattern of Urban Elderly Females, Delhi, India. Collegium Antropologicum. 2003;29(2):493-498.
4. Santos JL. Anthropometric Measurement in The Elderly Population of Santiago, Chile. The International Journal of Applied and Basic Nutritional Sciences. 2004;20:452-457.
5. Gavriilidou M, Pihlsgård, Elmståhl. High Degree of BMI Misclassification of Malnutrition among Swedish Elderly Population: Age-Adjusted Height Estimation using Knee Height and Demispan. European Journal of Clinical Nutrition. 2015;69:565-571.
6. Li ETS, Tang EKY, Wong CYM. Predicting Stature from Knee Height in Chinese Elderly Subjects. Asia Pacific Journal Clinical Nutrition. 2000;9(4):252-255.
7. Mohanty SP, Suresh B, Sreekumaran N. The Use of Arm Span as a Predictor of Height: a Study of South Indian Women. Journal Orthopaedic Surgery. 2001;1:19-23.
8. Fogal AS, Sylvia CCF, Silvia EP. Stature Estimation Using The Knee Height Measurement Amongst Brazilian Elderly. Nutricion Hospitalaria. 2015;31(2):829-834.
9. Wan H, Daniel G, Paul K. An Aging World: International Population Reports. Departments of Health and Human Services National Institutes of Health: United States Census Bureau. 2016;1:31-32.
10. Formayoza. Relationship between Characteristics, Level of Education, Economic Status, Physical Activity and Pain History with Elderly Nutritional Status (Study at Nanggalo Public Health Center, Padang City) (Hubungan Karakteristik, Tingkat Pendidikan, Status Ekonomi, Aktifitas Fisik dan Riwayat Sakit dengan Status Gizi Lansia (Studi di Puskesmas Kecamatan Nanggalo Kota Padang)). Graduate Thesis. Jakarta: Faculty of Public Health, Indonesia University; 2006.
11. Schueren MAE, Sabine L, Oscar JV. Prevalence and Determinants for Malnutrition in Geriatric Outpatients. Journal Clinical Nutrition. 2013;32:1007-1011.
12. Notoatmodjo S. Health Research Methodology (Metode Penelitian Kesehatan). Jakarta: Rineka Cipta; 2012.
13. Etisa AM, Niken P, Yudomurti. Body Height Measured by Knee Height Using Chumlea Formulas in Elderly (Tinggi Badan yang Diukur berdasarkan Tinggi Lutut Menggunakan Rumus Chumlea pada Lansia). Media Medika Indonesia. 2012;46(1):1-6.
14. Benjamin MA, Adam DS. Allometry and Apparent Paradoxes in Human Limb Proportions: Implications for Scaling Factors. American Journal of Physical Anthropology. 2011;144(1):382-391.
15. Brown JK, Whittemore KT, Knapp TR. Is Arm span an Accurate Measure of Height in Young Middle Age Adults. Clinical Nursing Research. 2000;9(1):84-94.
16. Samuel. Major Racial Groups of The World and Their Characteristics [Internet]. Eacharya. Available from: http://eacharya.inflibnet.ac.in/data-server/eacharya-documents/5717528c8ae36ce69422587d_INFIEP_304/112/ET/304-112-ET-V1-S1__file1.pdf
17. Tiwari P. Major Physical Characteristics of Racial Groups. [Internet]. Geography Notes. Available from: http://www.geographynotes.com/human-geography/major-physical-characteristics-of-racial-groups/1012
18. Andrews JM. The Varieties of Human Physique: Physical Anthropology. [Internet]. Wiley. pg. 470-474. Available from: http://onlinelibrary.wiley.com/doi/10.1525/aa.1941.43.3.02a00260/pdf
19. Oroles F. The Determining Factors in The Formation of The Three Body Types (Ectomorph, Mesomorph and Endomorph). [Internet]. University Politehnica of Bucharest. Available from: http://www.conferinte-defs.ase.ro/2016/pdf/Florescu%20O.pdf